
Perspectives on the Use of M&S to Support Systems Acquisition

Judith Dahmann, The MITRE Corporation

7515 Colshire Drive, MS N220
McLean VA 22102-7508
703-883-1363
jdahmann@mitre.org

Zach Furness, The MITRE Corporation

7515 Colshire Drive, MS W636
McLean VA 22102-7508
703-824-3447
zfurness@mitre.org

Sidney Kissin, PEO Metrics

540 Moorings Circle
Arnold MD 21012
703-607-0593
sidney.kissin@osd.mil

Stuart Starr, The MITRE Corporation

7515 Colshire Drive, MS N650
McLean VA 22102-7508
703-883-5494
starr@mitre.org

Abstract

There is increased interest in the use of innovative modeling and simulation (M&S) tools to support the acquisition of defense systems. This paper discusses the results of two recent activities that were convened to shed light on this issue: a study by the National Research Council (NRC) entitled "Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success" and a workshop sponsored by the Office of the Secretary of Defense (OSD) on "M&S to Support C4ISR Acquisition and Transformation". The paper concludes by identifying the major common themes that emerged from the two activities and potential next steps.

A. Introduction

This paper identifies and discusses recent perspectives that have emerged on the use of modeling and simulation (M&S) to support the acquisition of defense systems. The paper begins by identifying and analyzing key trends that are likely to affect the acquisition of defense systems over the next decade. Consistent with these factors, a vision for a reformed acquisition process, simulation based acquisition (SBA), is introduced. The paper then derives key insights on SBA that have emerged from several recent events. The first event is a National Research Council (NRC) study entitled "Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success". The basic facts of the study are summarized and the major study recommendations are presented and discussed. That is followed by a description of the second event, a workshop sponsored by the Office of the Secretary of Defense (OSD) on M&S to Support C4ISR Acquisition and Transformation. That event is characterized by the insights that were developed in plenary and a summary of the major recommendations that were developed by the

Paper presented at the RTO NMSG Conference on "NATO-PfP/Industry/National Modelling and Simulation Partnerships", held in Paris, France, 24-25 October 2002, and published in RTO-MP-094.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 00 NOV 2003		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Perspectives on the Use of M&S to Support Systems Acquisition				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The MITRE Corporation 7515 Colshire Drive, MS N220 McLean VA 22102-7508				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM001655., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 25	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Perspectives on the Use of M&S to Support Systems Acquisition

workshop's break-out groups. The paper concludes by identifying the major common themes that emerged from the two events and potential next steps.

B. Context

As context for this paper, this section briefly analyzes trends affecting Department of Defense (DoD) acquisition needs and formulates a new acquisition vision.

B.1 Trends Affecting DoD Acquisition Needs

There are several major trends that will affect the M&S and ancillary tools that are needed to support the acquisition of military systems. These trends are depicted in Figure 1. The following discussion identifies these trends and discusses their implications on the use of M&S in the acquisition process.

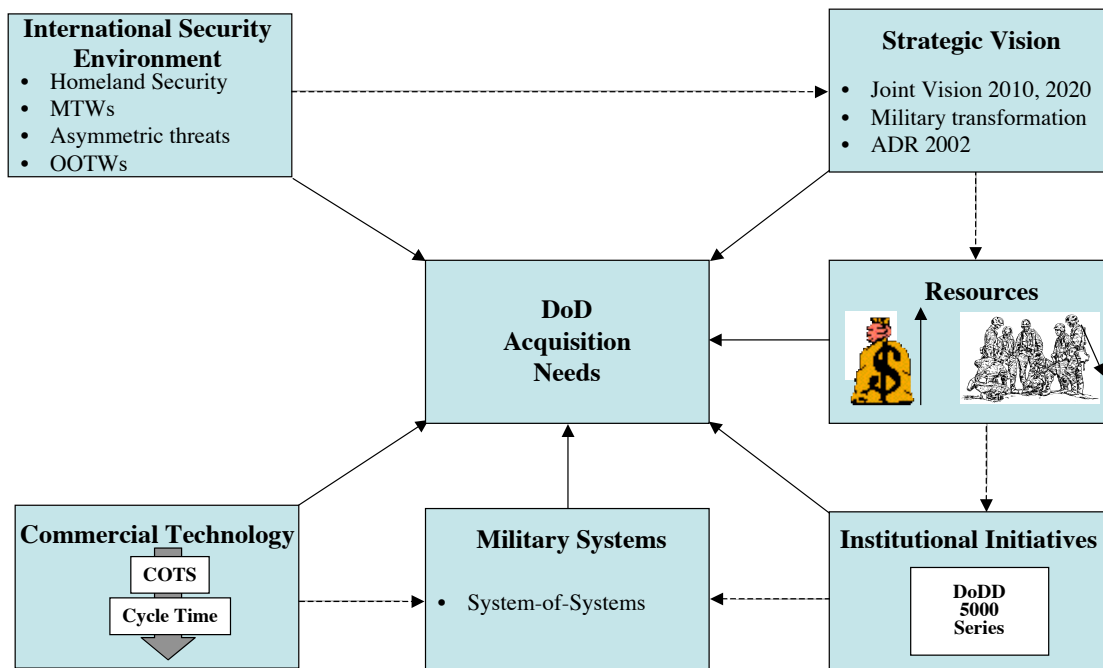


Figure 1. Trends Affecting DoD Acquisition Needs

B.1.1 International Security Environment

The dawn of the 21st century has given rise to several fundamental changes in the international security environment. In the aftermath of September 11, 2001, there has been a dramatic increase in the attention paid to homeland security issues. Although the interest in potential major theater wars (MTWs) has also persisted, the recent focus has been on states that have access to chemical, biological, radiological, nuclear, and explosives (CBRNE) weapons. There is particular concern that these actors could use such weapons asymmetrically to pose anti-access issues that would create challenges for conventional forces. In addition, there is the realization that operations other than war (OOTW) (e.g., peacemaking, peacekeeping) are likely to recur, prompting the need to create *ad hoc* coalitions of willing nation states, international organizations, and non-governmental organizations.

Currently, there are few existing M&S that are well suited to address these issues. Thus, a new generation of M&S must be developed for these conflict environments that can support the trade-off studies needed to explore meaningful break-points in mission capabilities.

B.1.2 Strategic Vision

Over the last five years, a series of strategic products has emerged to guide the DoD's responses to these changes in the international security environment. At the base of these products lies Joint Vision 2010 and 2020 (Reference 1, 2) issued by the Chairman, Joint Chiefs of Staffs. Those visions emphasized that enhanced command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) will be the critical enabler for transforming the US's military force. Building on that vision, the Secretary of Defense in his Annual Report to the President and the Congress (ADR) (Reference 3) has identified six transformational objectives to focus the actions of the military. Those objectives also identify C4ISR as a major direct and indirect factor in the proposed transformation.

At present, there are relatively few M&S that credibly reflect C4ISR processes and systems. Thus, efforts are needed to deal creatively with this dimension of the problem, either by incorporating the effects of C4ISR in existing or proposed M&S, or by interfacing M&S with operational C4ISR systems. In addition, those latter experiences could be used to collect the data needed to improve modeling of C4ISR.

B.1.3 Resource Trends

Within the last year, there has been a renewed commitment by the US to devote increasing resources to national security. This increase reflects the demands from multiple needs: enhanced attention to homeland security, as well as the need to sustain selected legacy forces while pursuing transformational goals. Even though those resources are substantial, they are inadequate to deal with all the national security demands for resources. As an example, the Crusader, a highly automated artillery system, was cancelled to free up resources for more pressing systems. Thus, there will continue to be strong pressure to acquire the "right things" as well as acquiring "things right". Consequently, there will be increasing need for M&S tools that will help the senior leadership understand which are the "right things" with an emphasis on proceeding with only those ongoing acquisitions which support future system-of-systems concepts.

In order to reduce the military footprint in the theater and reduce resource requirements, there is interest in acquiring systems that require fewer personnel to operate them. To support that concept, there is interest in acquiring M&S that support much more effective education and training, any-where, any-time.

B.1.4 Institutional Initiatives

There is growing concern that the current acquisition process is stultifying, limiting the Program Manager's creativity and flexibility, and is too focused on the acquisition of individual systems vice military capability. As a consequence, a revision of DoD Directive (DoDD) 5000 is in progress that is briefer, less directive, and incorporates system-of-systems acquisition. Current drafts of the revised documents emphasize processes such as evolutionary acquisition and spiral development. Clearly, there is a need for enhanced M&S tools and ancillary data to help implement these concepts, particularly to address the complexities inherent in mission capabilities and system-of-systems acquisition issues.

B.1.5 Military Systems

Historically, the acquisition of systems focused on individual platforms, keeping most key operational and support factors fixed (e.g., concepts of operation, education and training). There is increased understanding that one needs to acquire and assemble systems-of-systems to realize enhanced mission effectiveness. This appreciation has led to increased emphasis on interoperability along with the recognition that testbeds or environments are needed to assess, achieve, and sustain it. In addition, the interest in transforming the military has stimulated the re-thinking and re-orienting of all aspects of doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTML-PF). Currently, existing tools lack the flexibility to vary all of these factors simultaneously. Thus, attention is being given to new M&S techniques (e.g., agent based modeling) which have the potential to deal flexibly with a broader set of these factors and their interrelationships.

B.1.6 Commercial Technology

In recent years, there has been a dramatic increase in the use of commercial-off-the-shelf (COTS) technology in military systems, particularly for C4ISR systems. These COTS products tend to be highly dynamic, spawning upgraded versions on the order of 6 to 18 months. Since this is much shorter than the historical DoD acquisition cycle, it is stimulating the use of innovative acquisition strategies (e.g., evolutionary acquisition) to avoid fielding products that are technologically obsolete. To support this process, there is a need for M&S testbeds to explore the value of injecting new technology on mission effectiveness, in a timely manner.

B.2 Acquisition Vision

To respond to these major trends, a vision of a new acquisition paradigm is emerging that yields substantial reductions in time, resources, risk, and total ownership costs throughout the life cycle process, while simultaneously increasing the system's quality, military worth, and supportability.

In order to achieve those benefits, it is perceived that the intelligent use of simulations is the critical enabler. These simulations must be robust, used collaboratively by all of the stakeholders involved in the acquisition, and integrated across the phases and functions of the system life cycle. In addition, to take full advantage of the investments in these simulations, steps should be taken to ensure that they are reused to support other, related system programs. This philosophy of employing M&S extensively and consistently within and across program lines is often referred to as Simulation Based Acquisition (SBA).

C. Key Insights

Over the last several years, several activities have explored options to enhance the use of M&S to support system acquisition. This section characterizes the insights that have emerged from two of those activities: a NRC study and an OSD-sponsored workshop.

C.1 National Research Council Study Results

In 2001, the Defense Modeling & Simulation Office (DMSO) requested that the NRC investigate next-generation evolutionary and revolutionary M&S capabilities that will support enhanced defense systems acquisition. The NRC is the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing analytical services to the government, the public, and the scientific and engineering communities. The study was chaired by Peter Castro, Eastman Kodak Corporation, and performed by a committee of twelve experts on M&S, manufacturing, and acquisition, drawn from academia (i.e., Harvard, California Institute of Technology, University of Arizona, Carnegie Mellon University, Old Dominion University, Johns Hopkins University/Applied Physics Lab, and the University of Wisconsin-Milwaukee), industry (i.e., Lockheed Martin, Ford, GRCI), and Federally Funded Research & Development Centers (FFRDCs) (i.e., MITRE, and Sandia National Labs,). This group received extensive briefings from, and conducted in-depth discussions with, innovators in SBA in government and industry. The final report was issued in the summer of 2002 (Reference 4).

The NRC Panel proposed four, broad, inter-related recommendations. As a key enabler, it is vital that the community invest in appropriate technology and research. The results of these efforts will give rise to a community-wide infrastructure that supports increased consistency and integration. Use of that infrastructure will provide experience that will guide further use as well as pointing to important opportunities for further research. Finally, people and culture are the key factors: if the people and the culture in which they operate do not trust and embrace the creative application of M&S to acquisition, SBA will never become a wide-spread activity.

The Panel characterized this set of recommendations as a “virtuous auto-catalytic cycle”. That meant that each of the recommendations will serve to stimulate and reinforce the others. Thus, once a critical mass is achieved, the activities will be self-sustaining. However, it underscores the fact that failure to perform one or more of these recommendations could undermine the entire enterprise.

C.1.1 Technology and Research Recommendations

In the broad area of *technology and research*, the Panel recommended that “Long term R&D should be funded, conducted, and applied to enhance the science and technology base for M&S in ... manufacturing, acquisition, and life-cycle support of military systems.” To amplify on that overarching recommendation, the Panel formulated four subordinate recommendations for DoD:

- Conduct or support *basic research and development* in the following areas: modeling methods (e.g., scalability, multi-resolution and multi-viewpoint modeling, agent-based modeling); model integration (e.g., interoperability, composability); model correctness (e.g., verification, validation, and accreditation (VV&A)); standards (e.g., M&S standards for interoperability and modeling); methods and tools (e.g., for assistance in the translation of system requirements into system functionality); and domain-specific models (e.g., M&S for operations other than war).
- Enhance the ability to deal with *systems-of-systems*. This should include the generation of a library of composable system models, the ability to manage interactions among component systems efficiently, and the development of efficient experimental design techniques.
- Create a *research initiative at multiple universities*. This initiative should focus on the key M&S shortfalls identified by DoD program offices.
- Plan and execute the *transition of research into applications* as an integral part of the development process.

C.1.2 Infrastructure Recommendations

In the area of *infrastructure for M&S*, the Panel recommended that the community should “...Invest in ‘common good’ activities to encourage standards and strong infrastructure for M&S”. To clarify that recommendation, the panel formulated three subordinate recommendations for DoD:

- Institute *incentives* for program managers to develop M&S elements that contribute to the general infrastructure. This should include an annual competition for the best infrastructure contributions.
- Exploit common elements of M&S to develop a *common infrastructure* capable of supporting consistency and interoperability across programs. This infrastructure should include common repositories that can support multiple phases of a program as well as multiple programs, a trained M&S workforce, and an information technology infrastructure that will drive the advance of the needed M&S infrastructure.
- Advance the emergence of *common standards* for performance simulation and product modeling. To that end, DoD should remain actively engaged in commercial standards efforts, take the lead in the development of standards that lack commercial interest, and develop standard semantics for the data elements used in DoD acquisition related M&S.

C.1.3 Use of M&S Recommendations

In the broad area of the *use of M&S* in acquisition and manufacturing, the Panel recommended that “Process improvements should be undertaken to better support integration of M&S within DoD’s system acquisition process.” To expand on that overarching recommendation, the Panel formulated four subordinate recommendations for DoD:

- Expand M&S in the *concept exploration phase*, to ensure that we “build the right thing” as well as “building the thing right”. To that end, M&S should be used more extensively during the requirements process.
- Develop a *set of guidelines and best practices* for ownership rights among DoD and industry (with respect to M&S and data) to facilitate the potential for collaboration and the reuse of M&S.

Perspectives on the Use of M&S to Support Systems Acquisition

- Define how M&S should be *integrated* into the DoD system acquisition process. This should include the use of the maturity of the simulation support plan as an element in milestone decision reviews.
- Create and implement *incentives* for DoD Program Managers (PMs) to adopt best practices on M&S use.
- Define and undertake *pilot efforts* at the OSD level. These pilot efforts should be designed to explore cross-program benefits of M&S and system-of-systems issues.

C.1.4 Culture and Human Issues Recommendations

In the area of *culture and human issues*, the Panel recommended that "...DoD must provide leadership to initiate, support, and sustain a cultural change in the acquisition process." To amplify on that overarching recommendation the Panel formulated three subordinate recommendations for DoD:

- *Fundamentally transform* the current acquisition culture in DoD into one characterized by collaboration, cumulative learning, agility, risk tolerance, learning from failure, and appropriate rewards and penalties.
- DoD should take the lead in collaborating with academia and industry to build the *intellectual capital* needed to implement SBA. This should include the support of existing and developing academic degree programs in M&S, the establishment of a mentoring program, and the encouragement of individuals to view M&S as a "lifetime learning" endeavor.
- DoD should establish a *center of excellence* for M&S in SBA. This resource would help create and promulgate the desired acquisition culture and enhance DoD's ties to the academic community.

C.2 OSD Workshop Results

The purpose of the OSD Workshop was to identify high priority M&S needs and recommend associated policy changes and initiatives to support the acquisition and transformation of C4ISR systems. Note that by focusing on C4ISR systems, this activity was more restricted in scope than the NRC study that addressed the acquisition of all DoD systems. However, during the course of the workshop deliberations, there was a sense that many of the issues faced in the acquisition of C4ISR systems map to those of complex battle management systems that integrate C4ISR and weapons systems. It is envisioned that the results will provide input to a subsequent investment plan for M&S to support the acquisition and transformation of C4ISR systems.

The Workshop was sponsored by three organizations in the OSD. They include the Assistant Secretary of Defense (C3I), and two offices in the Undersecretary of Defense (Acquisition, Technology, and Logistics): the Interoperability Office and the Defense Modeling and Simulation Office. To ensure a strong industry component to the workshop, the AIAA Technical Committee on Information and C2 Systems worked cooperatively with the workshop planning group to provide knowledgeable participants across the areas and in the synthesis activity.

The heart of any workshop is the experts that are assembled to deliberate on the issues of interest. In this case, forty-four experts on acquisition, C4ISR, and modeling and simulation were brought together. These experts provided a balanced mix of representatives from government, industry, and FFRDCs.

In order to achieve the goals and objectives of the workshops, a series of plenary and break-out sessions were held. In plenary, the sponsors proved individual charges to the participants. That was followed by presentations on institutional perspectives with emphasis on the DoDD 5000, governing the acquisition of systems. The plenary session concluded with Service presentations on innovative activities to enhance the acquisition of complex systems.

Subsequently, the assembled experts were divided into break-out groups by system type (i.e., communications, sensors, C2 systems/information processing) and systems-of-systems. Those break-out groups began their deliberations with a list of strawman M&S capability objectives. They evaluated

associated M&S needs, and identified the highest priority M&S shortfalls. They subsequently identified options to ameliorate those highest priority shortfalls. The Workshop was held 2 - 4 April at the MITRE Corporation, McLean, VA (Reference 5).

C.2.1 Plenary Insights

The plenary session began with presentations by the workshop sponsors or their representatives. All see M&S as critical to their organization's mission effectiveness. With respect to systems-of-systems, all saw it as a wave of the future, which poses new M&S challenges for the community.

The presentation on DoD acquisition directives began by citing challenges in overcoming the shortfalls in the existing acquisition process (e.g., it takes too long, costs too much, and is incompatible with modern subsystem cycle times). The opportunities offered by the acquisition model described in the current version of DoDD 5000 were cited. It was stressed that the model emphasizes the use of evolutionary acquisition, anticipating the need to inject new technology periodically (e.g., on the order of every eighteen months to keep pace with developments in the information systems sector of the commercial world). Several enhanced roles for M&S in support of this new model were identified. These included support to Analyses of Alternatives (AoAs) in Concept & Technology Development (CDT), Early Operational Assessments (EOAs) in System Development & Demonstration (SDD), and Operational Test & Evaluation (OT&E) in Production & Deployment (P&D).

However, it was acknowledged that there are several major residual challenges in DoDD 5000 that require future action, particularly in the guidance it provides on system-of-systems acquisition. For example, since individual systems are acquired asynchronously, how do you do "full system demonstration" before the commitment to production or perform T&E of a full system-of-systems? In addition how do you deal with interoperability and supportability of a C4ISR system when multiple configurations are deployed, simultaneously? This latter issue is of particular concern to the US Army that must deal with the simultaneous fielding of large numbers of legacy, interim, and objective systems. As noted in Section B.1.4 of this paper, since the workshop was completed there has been renewed interest in revising the DoDD 5000 series to enable an acquisition policy environment that fosters efficiency, creativity, and innovation. Efforts to achieve those objectives are currently underway.

In the final segment of the plenary, representatives from the three Services described key initiatives. The Electronic Systems Command, US Air Force, is developing a Joint Synthetic Battlespace (JSB) to support the future acquisition and integration of C4ISR-weapon systems-of-systems. This effort has pursued a "top down" approach, systematically addressing the dimensions of leadership, policy, process, technology, and resources. To take advantage of the extensive investment in M&S environments that have been made, this approach strongly emphasizes Service/industry collaboration.

Second, the US Navy is developing a Naval Collaborative Engineering Environment to support Program Executive Officers (PEOs) and PMs in meeting the Service's integration and interoperability requirements. They have adopted a framework for integrated system evolution that emphasizes the separation of data and a suite of multi-functional tools to support the initial phase of acquisition (e.g., mission capability packages supported by Operational Requirement Documents, Analyses of Alternatives).

Finally, the US Army completed the Service perspectives by describing current thoughts on the C4ISR-weapon system mix for the proposed Future Combat System (FCS) and the tools that are evolving to support the acquisition of that capability. In the latter area, they are creating an arena to evaluate future system concepts drawing on the capabilities developed at the Joint Precision Strike Demonstration (JPSD) and the Joint Virtual Battlespace (JVB). The philosophy is to integrate existing M&S tools and resources from a variety of sources (e.g., US Army Research, Development, and Engineering Centers (RDECs), National Labs) and to augment them via a spiral build to address specific system acquisitions.

Perspectives on the Use of M&S to Support Systems Acquisition

Looking across the presentations by the three Services, it is noteworthy that cross-Service collaboration on their activities is ongoing and increasing. Since each Service has employed a different, but complementary, approach to the issue, such collaboration has the potential to enhance the quality of each Service's environments and to minimize duplication of efforts. From a system-of-systems standpoint, integrating across the three Services and with coalition partners remains a key challenge.

C.2.2 Break-out Group Insights

Figure 2 provides a framework that identifies a set of M&S-related categories that must be addressed by the acquisition community. The break-out groups concluded that if future C4ISR assessments are to be planned and conducted successfully in a dynamic environment *and* supported effectively by the M&S community, we must consistently address *all* of these factors in a balanced way. The backdrop for these factors is set by the *cultures* of the many communities that must participate in future C4ISR acquisitions. To remind us of the importance of the cultural dimension, one facet of the pyramid is labeled "change in attitude, culture".

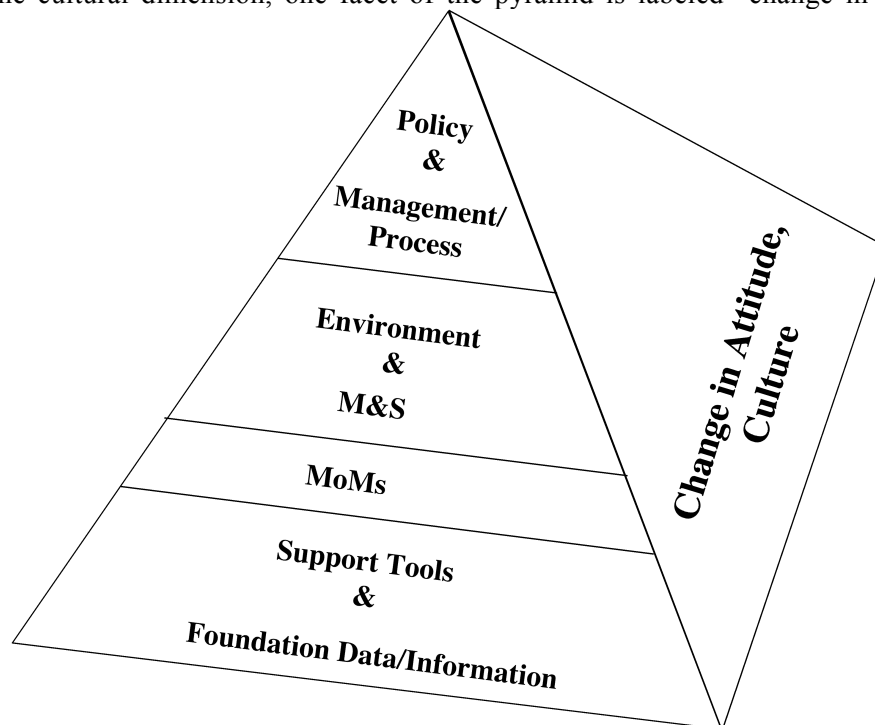


Figure 2. Framework for Recommendations

The base of the framework rests on support tools and foundation data and information. It subsumes repositories of critically needed information (e.g., environmental data). Building on the foundation data/information is a set of broadly needed support tools. These include readily tailorable and reusable scenarios. Resting on these support tools, are sets of hierarchies of measures of merit (MoMs). These range from measures of C4ISR system performance (e.g., bandwidth of communications systems) to overall measures of campaign effectiveness (e.g., the time required to halt an invading army). Once the MoMs have been identified, it serves to clarify the individual M&S modules that are needed to evaluate the measures of interest. These M&S modules are then federated into environments that enable the acquirer to assess the measures efficiently over the requisite set of scenarios and assumptions. In order to develop and employ these environments, it is necessary to have sound policy, management, and associated processes to guide the acquirer in applying M&S appropriately in the acquisition process.

In the area of policy, management and processes, several broad needs were identified. First, the system-of-systems panel called for a revisit of DoDD 5000 to ensure that it addressed critical system-of-systems issues adequately. For example, there was a need to address mission capabilities based decision-making vice individual system decision making. Second, there is a need to develop and provide government/contractor access to authoritative M&S and repositories for data, algorithms, joint scenarios, and synthetic natural

environments. Finally, the system-of-systems panel called out the need to derive insights from system-of-systems events (e.g., exercises, experiments). In order to do so, there is a need for sufficient funding, authority, and responsibility to capture and exploit important data from these events.

Each of the panels identified major needs in the area of acquisition environments. The broadest need was articulated by the system-of-systems panel that called out the need for secure, distributed, scalable, responsive, standards-based, collaborative engineering environments. Specific attributes of these environments were identified by the other panels. For example, the C2 panel called out the need for these environments to be interoperable with those of industry and to evolve throughout the acquisition process. The remaining panels noted the need for these environments to be able to interface with other systems, M&S, humans in the loop, and hardware in the loop.

Each of the panels identified major needs in the area of M&S. At a macro-level, the system-of-systems panel called out the need for a reference model for alternative levels of interest (e.g., system, function, mission, campaign) that would help identify key M&S capabilities and shortfalls. Several of the other panels identified specific M&S that were needed. These included communications models appropriate for system-of-system level analyses and network operations support, planning, and training; high level M&S that could support quick turn-around assessments for sensor trade studies; the ability to model information infrastructures; and M&S that featured better representations of decision making processes in C2.

There was general agreement that a hierarchy of MoMs is needed that would support assessments of the impact of C4ISR systems on mission effectiveness. This becomes particularly important in addressing system-of-systems issues, where MoMs are needed which reflect the performance of the system-of-systems capabilities as well as the contribution of individual systems. In the discussion, it was noted that NATO's evolving Code of Best Practice for C2 Assessment (Reference 6) is an excellent point of departure to pursue the development of those MoMs. These analytic constructs are critical if M&S is to be an effective tool.

Several panels identified the need for support tools to enhance the ease of use and responsiveness of M&S. In particular, it was stated that there is a need for reusable, tailorable scenarios; a joint library with an extensive scenario set (including Blue force laydowns); and common environmental representations.

Finally, several of the panels identified the need for key foundation data and information. From a system-of-systems perspective, it was observed that there is a need for synchronization points for past, current, and future system performance data. In addition, needs were identified for common standards for inputs to drive models and the identification of architectural data to link architectural representations to executable simulations.

D. Summary

In order to support the acquisition and transformation of C4ISR systems, a clear “bottom line” emerged from these recent initiatives. First, both events emphasized that it is essential that a cultural transformation be undertaken in the acquisition enterprise. This includes strong institutional leadership, the implementation of appropriate incentives, and the institutionalization of an effective education and training effort. Second, it was concluded that a system-of-systems perspective is vital. It is no longer viable to restrict acquisition to a single system, in isolation. Third, M&S was seen to be a critical enabler of the acquisition process. In particular, a strong, integrated M&S capability is required, in two dimensions. The M&S capability must support the full life cycle of an individual acquisition (i.e., intra-program) as well as cross-program acquisition (i.e., inter-program). Finally, in order to meet the M&S needs of the acquisition community, a balanced set of M&S initiatives must be pursued. These range from initiatives on creating and making available foundation data/information through the formulation of revised high level policy governing system-of-systems acquisition.

As a consequence of these events, preliminary plans for M&S investments to support C4ISR acquisitions are emerging. There is interest in pursuing a range of initiatives including a study of the tools needed to assess

Perspectives on the Use of M&S to Support Systems Acquisition

proposed operational, system, and technical architectural products, an assessment of existing and emerging M&S applications to support SBA, an assessment of the state-of-the-practice in integrated M&S environments, and, ultimately, an application of these tools and techniques to the evolving operational and systems concepts for network centric warfare.

E. References

1. Chairman, Joint Chiefs of Staff, Joint Vision 2010, Washington D.C.: US Government Printing Office, July 1996 (available at www.dtic.mil/jv2010/jv2010.pdf)
2. Chairman, Joint Chiefs of Staff, Joint Vision 2020, Washington D.C.: US Government Printing Office, June 2000 (available at www.dtic.mil/jv2020/jv2020a.pdf)
3. Secretary of Defense, Annual Defense Report to the President and the Congress, August 2002 (available at www.defense.link.mil/execsec/adr2002/toc2002.htm)
4. National Research Council, "Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success", Washington, D.C., 2002.
5. Judith Dahmann, et al, " M&S to Support C4ISR Acquisition and Transformation", Seventh International Command and Control Research and Technology Conference, Quebec City, Quebec, Canada, 16 - 20 September 2002.
6. NATO Code of Best Practice (COBP) on the Assessment of C2, RTO Technical Report AC/323(SAS)TP/4 (Hull, Que.: Communication Group, Inc., March 1999)

F. Acknowledgements

The four authors of this paper organized, conducted, and documented the OSD Workshop on "M&S to Support C4ISR Acquisition and Transformation". One of the authors (Stuart Starr) was also a member of NRC Panel that wrote the report "Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success".

Perspectives on the Use of M&S to Support Systems Acquisition

Judith Dahmann

Zach Furness

Sidney Kissin

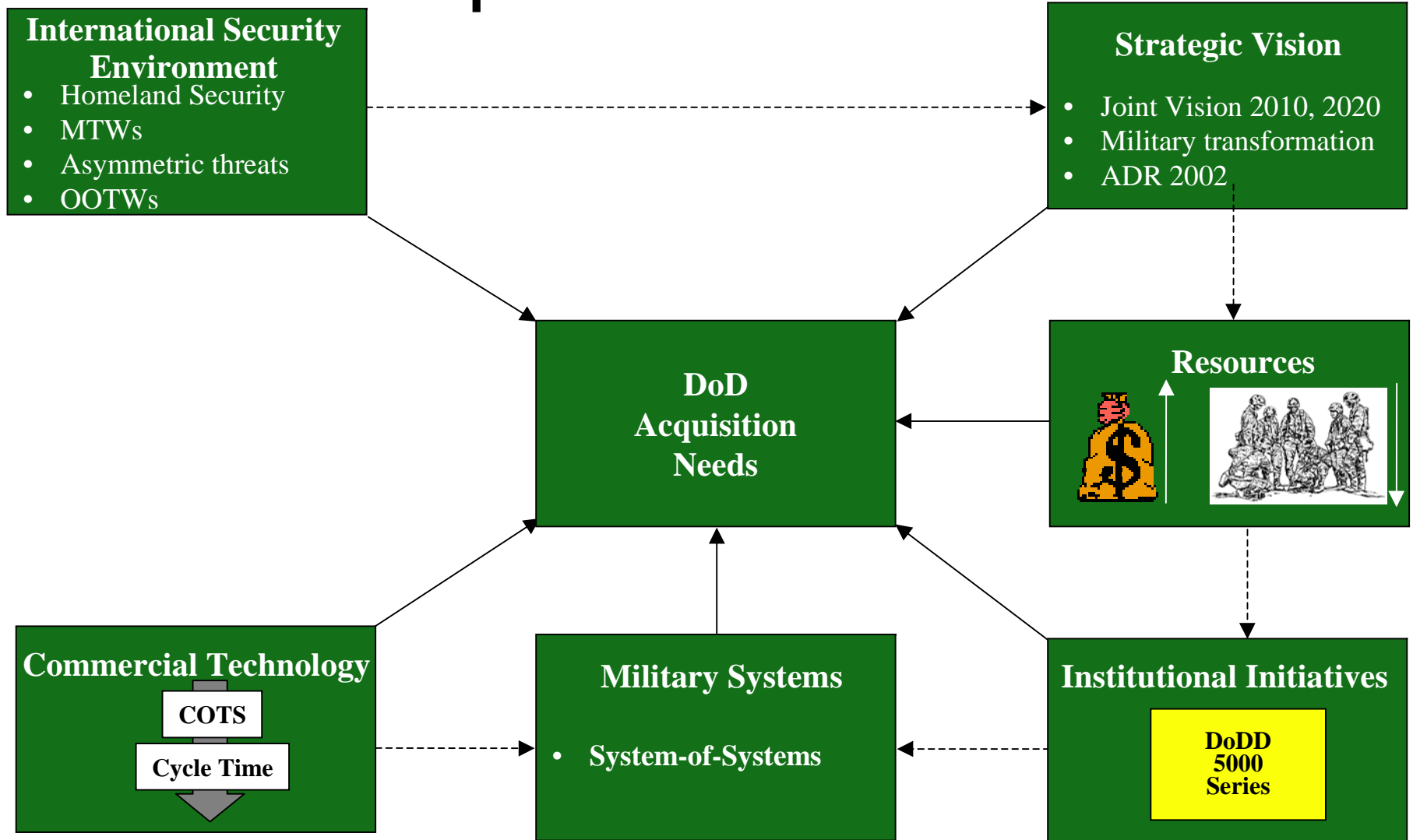
Stuart Starr

24 - 25 October 2002

Agenda

- Context
- Key Insights
 - National Research Council Study
 - OSD Workshop
- Summary

Trends Affecting DoD Acquisition Needs



Acquisition Vision

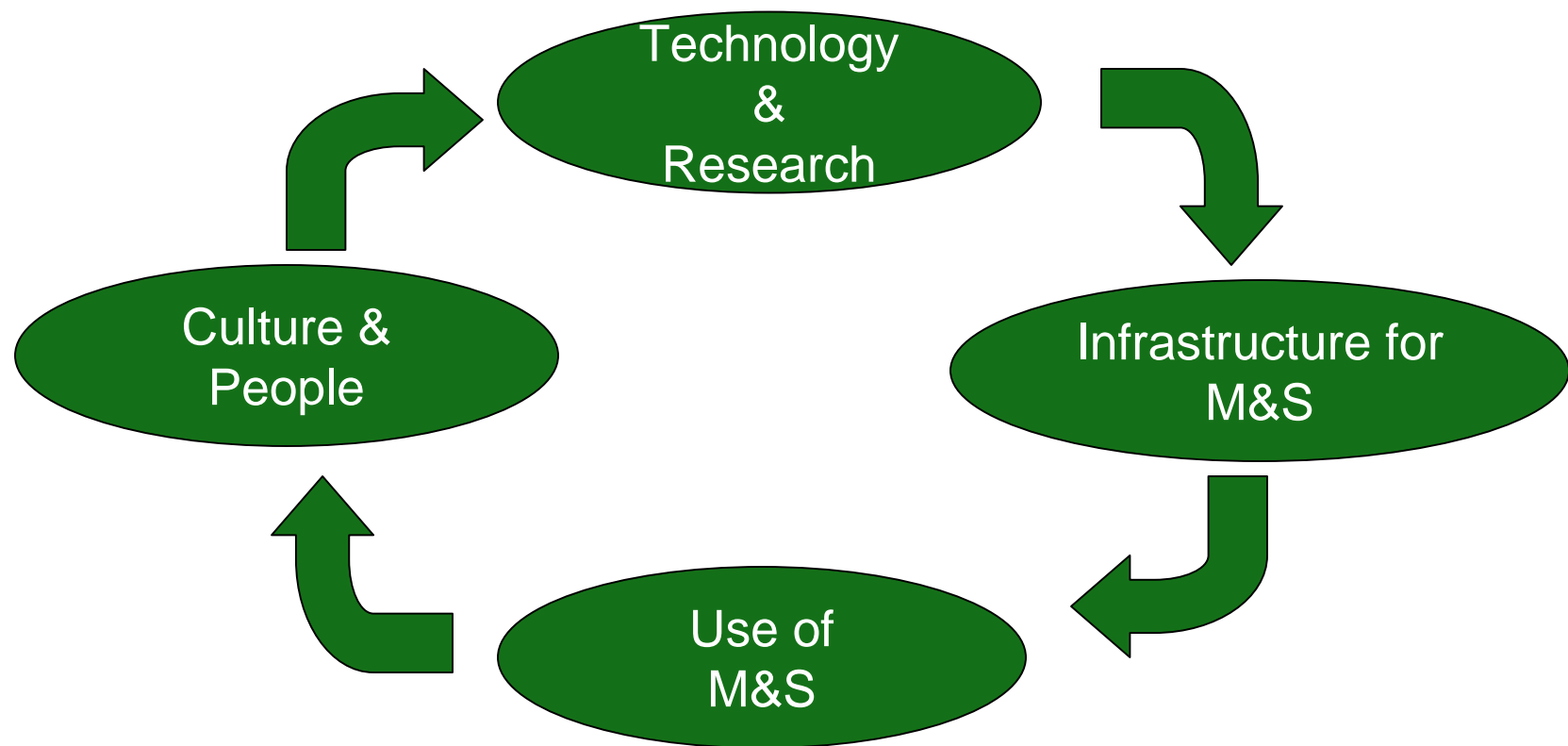
- What
 - *Reduce*: time, resources, risk, and total ownership costs throughout life cycle process
 - *Increase*: quality, military worth, and supportability of fielded systems
- How: Enabled by modeling, simulation, and information technology that is
 - Robust
 - Used collaboratively
 - Integrated across life cycle phases, functions, and programs

Simulation Based Acquisition

Essential NRC Study Facts

- **Why:** Investigate next-generation evolutionary and revolutionary M&S capabilities that will support enhanced defense systems acquisition
- **Who:**
 - Study requested by Defense Modeling & Simulation Office (DMSO)
 - Study chaired by Peter Castro, Eastman Kodak Corporation
 - Twelve panelists from academia, industry, FFRDCs
- **How:** Extensive briefings, discussions with government and industry innovators
- **When:** Report issued Summer 2002

Recommendations : A Virtuous, “Auto-Catalytic” Cycle



Major NRC Study

Recommendations (1 of 2)

- **Technology & Research:** “Long term R&D should be funded, conducted, and applied to enhance the science and technology base for M&S in ... manufacturing, acquisition, and life-cycle support of military systems”
 - Conduct basic *research & development*
 - Enhance the ability to deal with *systems-of-systems*
 - Create a *research initiative* at multiple universities
 - Plan and execute the *transition of research* into applications
- **Infrastructure for M&S:** “... Invest in “common good” activities to encourage adequate standards and a strong infrastructure for M&S”
 - Institute *incentives* for program managers to develop common M&S elements
 - Develop a *common infrastructure* capable of supporting cross-program consistency, interoperability
 - Advance *common standards*

Major NRC Study

Recommendations (2 of 2)

- **Use of M&S in Acquisition and Manufacturing:** “Process improvements should be undertaken to better support integration of M&S within DoD’s system acquisition process”
 - Expand M&S in the *concept exploration phase*
 - Develop a set of guidelines and best practices for *ownership rights*
 - Define how M&S should be *integrated* into the DoD system acquisition process
 - Create and implement *incentives* for DoD PMs on M&S use
 - Define and undertake *pilot efforts* at the OSD level
- **Culture and Human Issues:** “... DoD must provide leadership to initiate, support, and sustain a cultural change in the acquisition process”
 - *Fundamentally transform* the current acquisition culture in DoD
 - Build *intellectual capital* needed to implement SBA
 - Establish a *center of excellence* for M&S in SBA

Essential OSD Workshop Facts

- **Why:** Provide input to an *investment plan* for M&S to support the acquisition and transformation of C4ISR systems
- **Who:**
 - Three sponsors: ASD(C3I); OUSD(AT&L) {IO, DMSO}
 - Participants: 44 experts from government, industry, FFRDCs
- **How:**
 - Plenary: Perspectives of sponsors, OSD, Services
 - Break-out groups: Organized by System type (Communications, Sensors, C2/Information Processing); Systems-of-Systems
- **Where & When:** The MITRE Corporation, McLean, VA, 2 - 4 April 2002

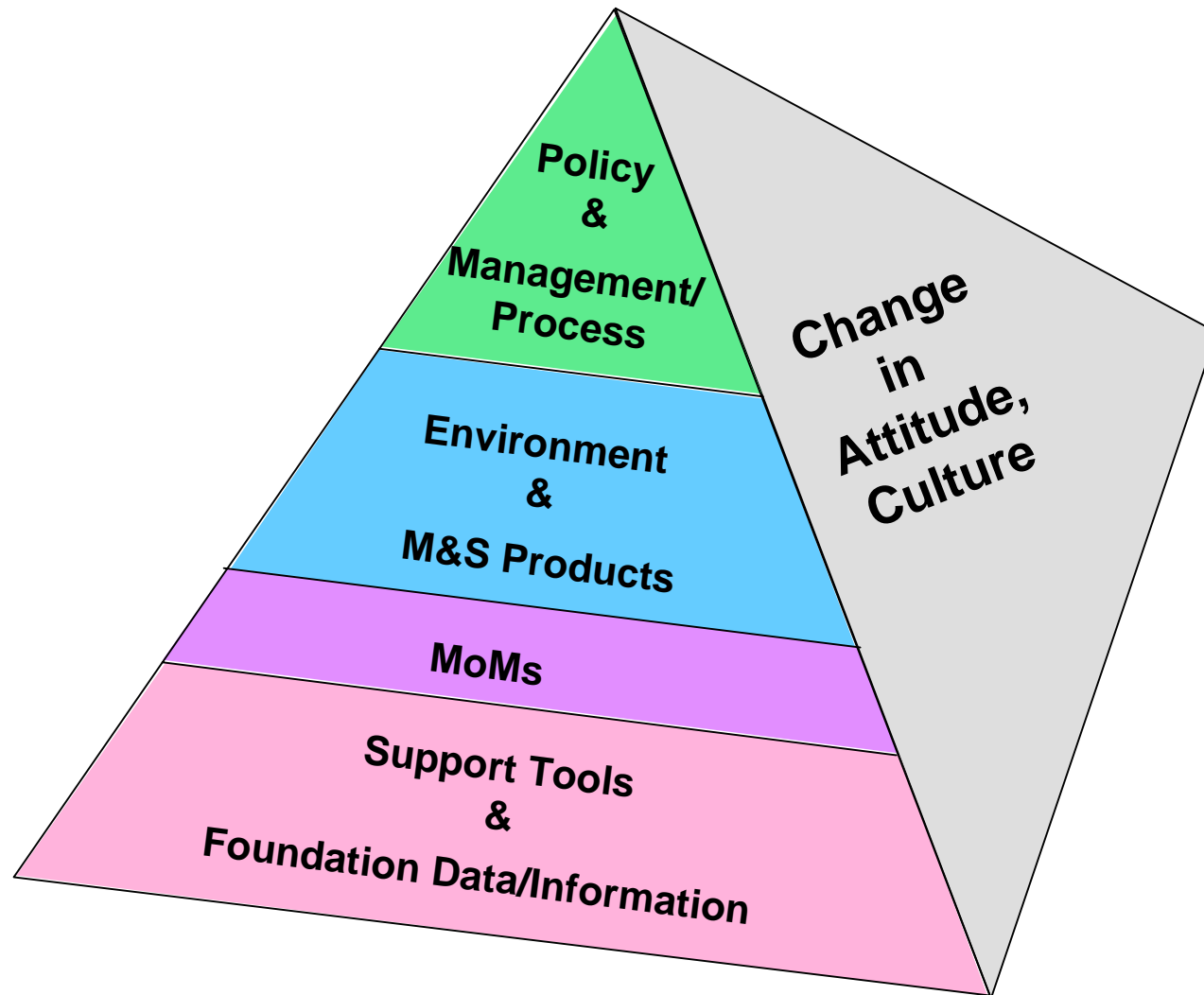
Plenary Insights (1 of 2)

- Sponsors' perspectives: Systems-of-systems are perceived as
 - The wave of the future
 - A major challenge for the M&S community
- Institutional perspectives
 - Acquisition process is beset with major problems (e.g., takes too long; costs too much; incompatible with modern subsystem cycle times)
 - Although the DoDD 5000 model emphasizes Evolutionary Acquisition it does *not* address system-of-system issues adequately

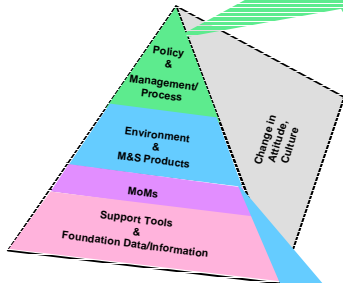
Plenary Insights (2 of 2)

- Service Perspectives
 - All are developing M&S environments to support the acquisition of Systems-of-Systems; e.g.,
 - US Air Force: Joint Synthetic Battlespace (JSB)
 - US Navy: Collaborative Engineering Environment (CEE)
 - US Army: Joint Virtual Battlespace (JVB)
 - There are interesting opportunities to collaborate and coordinate efforts

Framework for Recommendations



Summary of Major Recommendations (1 of 2)



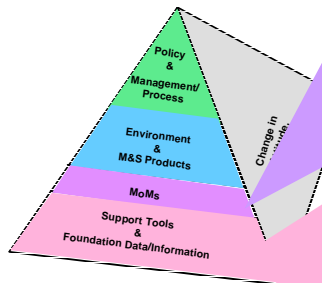
- **Policy and Management/Processes:**

- Revise DoDD 5000 to
 - Clarify the acquisition of a system-of-systems
 - Focus acquisition process on achieving mission capability
- Provide access to M&S, data
- Derive insights from system-of-systems events

- **Environments and M&S products:**

- Create shared collaborative environments in which to address interoperability issues
- Develop a reference model of cross-functional, cross-hierarchy M&S

Summary of Major Recommendations (2 of 2)



- **MoMs:**

- Develop sets of measures of system performance linked to measures of mission effectiveness

- **Support Tools and Foundation Data/Information:**

- Create common environmental representations and libraries of reusable scenarios
- Create easily accessible, broadly available data on architectures, systems performance, organizational behavior

Summary

- In order to support the acquisition of future DoD systems
 - *A cultural transformation* is essential
 - *A system-of-systems* perspective is vital
 - *A strong, integrated* M&S capability is required
 - *A balanced set* of M&S initiatives (e.g., from policy through foundation data/information) must be pursued to achieve the needed M&S capability